0050641

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

99-EAP-276

APR 27 1999

Mr. D. R. Sherwood
U.S. Environmental Protection Agency
712 Swift Boulevard, Suite 5
Richland, Washington 99352

Dear Mr. Sherwood:

TANK 241-Z-361 MAXIMAL EMISSION RATE ESTIMATES

The purpose of this letter is to inform you that the attached information will be included in the administrative record to support Tank 241-Z-361 sampling and characterization activities. This information represents an update to the estimate of potential air emissions that could be released during the venting of the tank. The information was developed in consultation with Dennis Faulk of your staff.

The "Tank 241-A-361 Vapor Sampling and Analysis Plan, HNF-2867, Rev. 0, Appendix B Non-Radioactive Air Monitoring Plan For Controlling And Monitoring Emissions From Venting, Sampling And Purging Underground Storage Tank 241-Z-361," (Phase I SAP) was approved in January 1999. Since that time the U.S. Department of Energy has continued to evaluate the non-radioactive constituents potentially present in the tank to support development of the sludge-sampling plan. Several Toxic Air Pollutants (TAP) constituents that were not originally addressed in Appendix B of the Phase I SAP have been identified as potentially present in the sludge.

The attached calculations indicate that emission rates of toxic air pollutants and/or particulate matter will remain sufficiently low to ensure that the substantive requirements for applicable air quality standards are met. Therefore, no additional monitoring pollution controls are proposed.

The attachment provides conservative estimates of maximal emission rates. Since, the proposed activities are not expected to increase particulate matter emissions, only gaseous emission estimates are provided.

If you have any questions regarding the enclosed material, please do not hesitate to call me or Suzanne E. Clarke, of my staff, on (509) 373-4931.

Sincerely,

James E. Rasmussen

James E. Rasmussen, Director
Environmental Assurance, Permits,
and Policy Division

EAP:SEC

Attachment

cc w/attach:
Administrative Record, H6-08
Dennis Faulk, EPA

cc w/o attach:
D. M. Bogen, BWHC
A. M. Hopkins, FDH

Estimation of total Criteria and Toxic Air Pollutants (WAC 173-400 & 173-460) with the potential to be released during the venting of Tank 241-Z-361

The following calculations are intended to be worst case bounding estimates of the amount of compounds and classes of compounds (e.g, total VOC's and NOx) contained within Tank 241-Z-361. The estimates are not intended to reflect what is actually in the tank since data to accurately predict the actual amount and release rates of the compounds and classes of compounds is not available. The actual amount of the identified compounds are expected to be significantly less since transfers to the tank were performed with low pressure steam (temperature > 230 F), conservation of mass principles were ignored (e.g., available nitrogen to produce estimated quantity of NOx was also used to estimate maximum quantity of ammonia, the sludge is actually 33% liquid although the calculations assume 100% liquid, and finally, the salt strength of the solution was not taken into account. As the salt strength increases, the solubility of organic compounds generally decreases; thereby, the total amount of organic compounds in solution actually decreases (*Environmental Organic Chemisty,* by Schwarzenbach, Gschwend and Imboden, and *Chemical Properties Handbook,* by Carl Yaws).

Constants and definitions not defined in MathCad.

$ppm := \frac{1 \cdot gm}{1 \cdot 10^{6} \cdot gm}$ $\rho_{water} := .997045 \cdot \frac{gm}{cm^3}$ $T := (273 + 25) \cdot K$

$P := 1 \cdot atm$ $R_{gas} := 82.057 \cdot \frac{atm \cdot cm^3}{mole \cdot K}$ $mg := 1 \cdot 10^{-3} \cdot gm$ $\mu g := 1 \cdot 10^{-6} \cdot gm$

$MW_{H2O} := (2 \cdot 1.0079 + 15.9994) \cdot \frac{gm}{mole}$ $MW_{H2O} = 18.015 \cdot \frac{gm}{mole}$

Assume sludge is 100% by volume of low salt strength water:

$Volume_{liquid} := 20000 \cdot gal$ $Volume_{vapor} := 25000 \cdot gal$

For Carbon Tetrachloride (CCl4), H = Henry's Law Constant:
(Reference: Handbook of Physical Properties of Organic Chemicals, CRC Press)

$MW_{CCl4} := (12.011 + 4 \cdot 35.453) \cdot \frac{gm}{mole}$ $\qquad MW_{CCl4} = 153.823 \cdot \frac{gm}{mole}$

$H_{CCl4} := 2.76 \cdot 10^{-2} \cdot \frac{atm \cdot m^3}{mole}$ $\qquad Dilution\_Factor_{CCl4} := \frac{(174 + 86 + 54)}{2353}$

$C_{CCl4\_initial} := .0024 \cdot \frac{mole}{liter}$ $\qquad Dilution\_Factor_{CCl4} = 0.133$

(Initial Carbon Tetrachloride concentration from 15540-92-CAB-076)

$moles_{CCl4\_liquid} := Volume_{liquid} \cdot C_{CCl4\_initial} \cdot Dilution\_Factor_{CCl4}$

$moles_{CCl4\_liquid} = 24.247 \cdot mol$

$C_{CCl4} := \frac{moles_{CCl4\_liquid}}{Volume_{liquid}}$ $\qquad C_{CCl4} = 0.32 \cdot \frac{mole}{m^3}$

$P_{CCl4} := H_{CCl4} \cdot C_{CCl4}$ $\qquad P_{CCl4} = 8.84 \cdot 10^{-3} \cdot atm$

$moles_{CCl4\_vapor} := \frac{P_{CCl4} \cdot Volume_{vapor}}{R_{gas} \cdot T}$ $\qquad moles_{CCl4\_vapor} = 34.21 \cdot mole$

$Wt_{CCl4\_total} := \left(moles_{CCl4\_liquid} + moles_{CCl4\_vapor}\right) \cdot MW_{CCl4}$

$Wt_{CCl4\_total} = 19.82 \cdot lb$ $\qquad SQE_{CCl4} := 20 \cdot \frac{lb}{yr}$

The predicted Carbon Tetrachloride concentration is close to the SQE; therefore, will use dispersion modeling to verify that the offsite concentration is less than the ASIL. Offsite modeling was performed using dispersion factors from the ISC3 program (EPA-454/B-95-003a) based on runs performed by Rittmann (1996). In accordance with WAC 173-460-150, Table II, Carbon Tetrachloride has an ASIL value of 0.067 micrograms/meter^3 (annual average).

$$ASIL_{CCl4} := .067 \cdot \frac{\mu g}{m^3}$$

$$Concentration\_Factor_{200W} := .0585 \cdot \frac{\left(\frac{\mu g}{m^3}\right)}{\left(\frac{gm}{sec}\right)}$$ (Rittmann 1996)

$$Air\_Concentration_{CCl4} := \frac{\left(Wt_{CCl4\_total} \cdot Concentration\_Factor_{200W}\right)}{86400 \cdot sec}$$

$$Air\_Concentration_{CCl4} = 0.0061 \frac{\mu g}{m^3}$$

The predicted offsite air concentration is approximately 10 times less than the allowable offsite air concentration.

For Acetic Acid (CH3COOH), H = Henry's Law Constant, S = Total Solubility:
(Reference: Handbook of Physical Properties of Organic Compounds, CRC Press)

$MW_{AA} := (2 \cdot 12.011 + 4 \cdot 1.0079 + 2 \cdot 15.9994) \cdot \frac{gm}{mole}$ $\quad$ $MW_{AA} = 60.052 \cdot \frac{gm}{mole}$

$H_{AA} := 1.00 \cdot 10^{-7} \cdot \frac{atm \cdot m^3}{mole}$

Since acetic acid disassociates in water, base estimation on reported pH of tank assuming contribution is attributed solely to acetic acid.

$pH := 4$ $\quad$ $H_{ion} := 10^{-pH} \cdot \frac{mole}{liter}$ $\quad$ $H_{ion} = 1 \cdot 10^{-4} \cdot \frac{mole}{liter}$

$pK_{a\_AA} := 4.76$ $\quad$ (CRC Handbook of Chemistry & Physics, 78th Edition)

$K_{a\_AA} := 10^{-pK_{a\_AA}}$ $\quad$ $K_{a\_AA} = 1.738 \cdot 10^{-5}$

$Acetic\_Acid := \frac{(H_{ion})^2}{K_{a\_AA} \cdot \frac{mole}{liter}}$ $\quad$ $Acetic\_Acid = 5.754 \cdot 10^{-4} \cdot \frac{mole}{liter}$

$moles_{AA\_liquid} := Acetic\_Acid \cdot Volume_{liquid}$ $\quad$ $moles_{AA\_liquid} = 43.566 \cdot mole$

$C_{AA} := \frac{moles_{AA\_liquid}}{Volume_{liquid}}$ $\quad$ $C_{AA} = 5.754 \cdot 10^{-4} \cdot \frac{mole}{liter}$

$P_{AA} := H_{AA} \cdot C_{AA}$ $\quad$ $P_{AA} = 5.754 \cdot 10^{-8} \cdot atm$

$moles_{AA\_vapor} := \frac{P_{AA} \cdot Volume_{vapor}}{R_{gas} \cdot T}$ $\quad$ $moles_{AA\_vapor} = 2.227 \cdot 10^{-4} \cdot mole$

$Wt_{AA\_total} := (moles_{AA\_liquid} + moles_{AA\_vapor}) \cdot MW_{AA}$

$Wt_{AA\_total} = 5.768 \cdot lb$ $\quad$ $SQE_{AA} := 10500 \cdot \frac{lb}{yr}$

For Oxalic Acid (C2H2O4), H = Henry's Law Constant:
(Reference: Handbook of Physical Properties of Organic Chemicals, CRC Press)

$MW_{OA} := (2 \cdot 12.011 + 2 \cdot 1.0079 + 4 \cdot 15.9994) \cdot \frac{gm}{mole}$ $\quad MW_{OA} = 90.035 \cdot \frac{gm}{mole}$

$H_{OA} := 1.43 \cdot 10^{-1} \cdot \frac{atm \cdot m^3}{mole}$

Since oxalic acid disassociates in water, base estimation on reported pH of tank assuming contribution is attributed solely to oxalic acid.

$pH := 4$ $\quad H_{ion} := 10^{-pH} \cdot \frac{mole}{liter}$ $\quad H_{ion} = 1 \cdot 10^{-4} \cdot \frac{mole}{liter}$

$pK_{a\_OA} := 1.23$ $\quad$ (CRC Handbook of Chemistry & Physics, 78th Edition)

$K_{a\_OA} := 10^{-pK_{a\_OA}}$ $\quad K_{a\_OA} = 0.059$

$Oxalic\_Acid := \frac{H_{ion}^{2}}{K_{a\_OA} \cdot \frac{mole}{liter}}$ $\quad Oxalic\_Acid = 1.698 \cdot 10^{-7} \cdot \frac{mole}{liter}$

$moles_{OA\_liquid} := Oxalic\_Acid \cdot Volume_{liquid}$ $\quad moles_{OA\_liquid} = 0.013 \cdot mole$

$C_{OA} := \frac{moles_{OA\_liquid}}{Volume_{liquid}}$ $\quad C_{OA} = 1.698 \cdot 10^{-7} \cdot \frac{mole}{liter}$

$P_{OA} := H_{OA} \cdot C_{OA}$ $\quad P_{OA} = 2.428 \cdot 10^{-5} \cdot atm$

$moles_{OA\_vapor} := \frac{P_{OA} \cdot Volume_{vapor}}{R_{gas} \cdot T}$ $\quad moles_{OA\_vapor} = 0.094 \cdot mole$

$Wt_{OA\_total} := \left(moles_{OA\_liquid} + moles_{OA\_vapor}\right) \cdot MW_{OA}$

$Wt_{OA\_total} = 0.021 \cdot lb$ $\quad SQE_{OA} := 175 \cdot \frac{lb}{yr}$

For Acetone (2-Propanone) C3H6O, H = Henry's Law Constant, S = Solubility in water by weight: (Reference: Handbook of Physical Properties of Organic Chemistry, CRC Press)

$MW_{Acetone} := (3 \cdot 12.011 + 6 \cdot 1.0079 + 1 \cdot 15.9994) \cdot \frac{gm}{mole}$ $\quad MW_{Acetone} = 58.08 \cdot \frac{gm}{mole}$

$H_{Acetone} := 3.97 \cdot 10^{-5} \cdot \frac{atm \cdot m^3}{mole}$

Assume that the laboratory consumed 50 gallons of acetone per year and uniformily discharged quantity into the total volume of 2,353,000 gallons a year out the 241-Z-361 tank.

$Volume_{Acetone} := 50 \cdot gal$ $\quad Flowrate_{total} := 2353000 \cdot gal$

$\rho_{Acetone} := .7899 \cdot \frac{gm}{cm^3}$ $\quad \rho_{Acetone} = 6.592 \cdot \frac{lb}{gal}$

$Weight_{Acetone} := Volume_{Acetone} \cdot \rho_{Acetone}$ $\quad Weight_{Acetone} = 1.495 \cdot 10^5 \cdot gm$

$C_{Acetone} := \frac{Weight_{Acetone}}{Flowrate_{total} \cdot MW_{Acetone}}$ $\quad C_{Acetone} = 1.094 \cdot 10^{-3} \cdot \frac{mole}{gal}$

$moles_{Acetone\_liquid} := C_{Acetone} \cdot Volume_{liquid}$

$P_{Acetone} := H_{Acetone} \cdot C_{Acetone}$ $\quad P_{Acetone} = 1.147 \cdot 10^{-5} \cdot atm$

$moles_{Acetone\_vapor} := \frac{P_{Acetone} \cdot Volume_{vapor}}{R_{gas} \cdot T}$ $\quad moles_{Acetone\_vapor} = 0.044 \cdot mole$

$moles_{Acetone\_total} := \left(moles_{Acetone\_liquid} + moles_{Acetone\_vapor}\right)$

$moles_{Acetone\_total} = 21.924 \cdot mole$

$Wt_{Acetone\_total} := moles_{Acetone\_total} \cdot MW_{Acetone}$

$Wt_{Acetone\_total} = 2.8 \cdot lb$ $\quad SQE_{Acetone} := 43748 \cdot \frac{lb}{yr}$

For Chloroform (CHCl3), H = Henry's Law Constant, S = Solubility in water by weight:
(Reference: Handbook of Physical Properties of Organic Chemistry, CRC Press)

$MW_{Chloroform} := (1 \cdot 12.011 + 1 \cdot 1.0079 + 3 \cdot 35.453) \cdot \frac{gm}{mole}$ $\quad MW_{Chloroform} = 119.378 \frac{gm}{mole}$

$H_{Chloroform} := 3.67 \cdot 10^{-3} \cdot \frac{atm \cdot m^3}{mole}$

Assume that the laboratory consumed 50 gallons of Chloroform per year and uniformily discharged the quantity into the total volume of 2,353,000 gallons a year out the 241-Z-361 tank.

$Volume_{Chloroform} := 50 \cdot gal$ $\quad Flowrate_{total} := 2353000 \cdot gal$

$\rho_{Chloroform} := 1.4832 \cdot \frac{gm}{cm^3}$ $\quad \rho_{Chloroform} = 12.378 \frac{lb}{gal}$

$Weight_{Chloroform} := Volume_{Chloroform} \cdot \rho_{Chloroform}$ $\quad Weight_{Chloroform} = 2.807 \cdot 10^{5} \, gm$

$C_{Chloroform} := \frac{Weight_{Chloroform}}{Flowrate_{total} \cdot MW_{Chloroform}}$ $\quad C_{Chloroform} = 9.994 \cdot 10^{-4} \frac{mole}{gal}$

$moles_{Chloroform\_liquid} := C_{Chloroform} \cdot Volume_{liquid}$ $\quad moles_{Chloroform\_liquid} = 19.988 \, mole$

$C_{Chloroform} := \frac{moles_{Chloroform\_liquid}}{Volume_{liquid}}$ $\quad C_{Chloroform} = 2.64 \cdot 10^{-4} \frac{mole}{liter}$

$P_{Chloroform} := H_{Chloroform} \cdot C_{Chloroform}$ $\quad P_{Chloroform} = 9.689 \cdot 10^{-4} \, atm$

$moles_{Chloroform\_vapor} := \frac{P_{Chloroform} \cdot Volume_{vapor}}{R_{gas} \cdot T}$ $\quad moles_{Chloroform\_vapor} = 3.75 \, mole$

$moles_{Chloroform\_total} := (moles_{Chloroform\_liquid} + moles_{Chloroform\_vapor})$

$moles_{Chloroform\_total} = 23.738 \, mole$

$Wt_{Chloroform\_total} := moles_{Chloroform\_total} \cdot MW_{Chloroform}$

$Wt_{Chloroform\_total} = 6.2 \, lb$ $\quad SQE_{Chloroform} := 10 \cdot \frac{lb}{yr}$

For Dichlorodifluoromethane (CCl2F2), H = Henry's Law Constant:
(Reference: Handbook of Physical Properties of Organic Chemicals, CRC Press)

$MW_{CCl2F2} := (1 \cdot 12.011 + 2 \cdot 18.9984 + 2 \cdot 35.453) \cdot \frac{gm}{mole}$ $\quad MW_{CCl2F2} = 120.914 \, \frac{gm}{mole}$

The source of Dichlorodifluoromethane is the laboratory. Assume that Dichlorodifluoromethane is at the solubility limit within the laboratory stream.

$Dilution\_Factor_{CCl2F2} := \frac{174}{2353}$

$H_{CCl2F2} := .343 \cdot \frac{atm \cdot m^3}{mole}$ $\quad S_{CCl2F2} := 2.80 \cdot 10^2 \cdot \frac{mg}{liter}$

$moles_{CCl2F2\_liquid} := \frac{S_{CCl2F2} \cdot Volume_{liquid}}{MW_{CCl2F2}}$ $\quad moles_{CCl2F2\_liquid} = 175.318 \, mol$

$C_{CCl2F2} := \frac{moles_{CCl2F2\_liquid}}{Volume_{liquid}}$ $\quad C_{CCl2F2} = 2.316 \cdot 10^{-3} \, \frac{mole}{liter}$

$P_{CCl2F2} := H_{CCl2F2} \cdot C_{CCl2F2}$ $\quad P_{CCl2F2} = 0.794 \, atm$

$moles_{CCl2F2\_vapor} := \frac{P_{CCl2F2} \cdot Volume_{vapor}}{R_{gas} \cdot T}$ $\quad moles_{CCl2F2\_vapor} = 3.074 \cdot 10^3 \, mole$

$moles_{CCl2F2\_total} := (moles_{CCl2F2\_liquid} + moles_{CCl2F2\_vapor})$

$moles_{CCl2F2\_total} = 3.249 \cdot 10^3 \, mole$

$Wt_{CCl2F2\_total} := moles_{CCl2F2\_total} \cdot MW_{CCl2F2}$

$Wt_{CCl2F2\_total} = 866.2 \, lb$ $\quad SQE_{CCl2F2} := 22750 \cdot \frac{lb}{yr}$

For Ammonia (NH3) and NOx assume produced from the conversion of NO2/NO3. From HNF-1989, the total N available is based on 2 M NO3 and 0.01 M NO2 from process (table 4) which is 86,000 gallons/yr out of 2,350,000 gallons/yr to the tank.

$N_{available} := (2 + .01) \cdot \frac{mole}{liter} \cdot \frac{86000}{2350000} \cdot Volume_{liquid}$ $\qquad N_{available} = 5568.9 \cdot mole$

$MW_{NH3} := (1 \cdot 14.0067 + 3 \cdot 1.0079) \cdot \frac{gm}{mole}$

$NH3 := N_{available} \cdot MW_{NH3}$ $\qquad NH3 = 209.088 \cdot lb$ $\qquad SQE_{NH3} := 17500 \cdot \frac{lb}{yr}$

For NOx assume in the form of NO2:

$MW_{NO2} := (1 \cdot 14.0067 + 2 \cdot 15.9994) \cdot \frac{gm}{mole}$

$NO2 := N_{available} \cdot MW_{NO2}$ $\qquad NO2 = 564.825 \cdot lb$ $\qquad NO2 = 0.282 \cdot ton$

The exemption threshold level for nitrogen oxides is 2.0 tons/year [WAC 173-400-110-(5)(d)].

For Hydrofluoric Acid, did not have a Henry's Law Constant for; however, HNF1989, Table 6 reported a fluoride concentration of .004 gram/liter in the sludge. Assume all fluoride in the form of HF.

$MW_F := 18.9984 \cdot \frac{gm}{mole}$ $\qquad MW_{HF} := (1.0079 + 18.9984) \cdot \frac{gm}{mole}$

$C_{HF} := .004 \cdot \frac{gm}{liter} \cdot \frac{MW_{HF}}{MW_F}$ $\qquad C_{HF} = 4.212 \cdot 10^{-3} \ \frac{gm}{liter}$ $\qquad C_{HF} = 3.515 \cdot 10^{-5} \ \frac{lb}{gal}$

$Wt_{HF\_total} := C_{HF} \cdot Volume_{liquid}$ $\qquad Wt_{HF\_total} = 0.703 \cdot lb$

$SQE_{HF} := 175 \cdot \frac{lb}{yr}$ (SQE is based on as F)

For alpha-Naphthylamine (1-Naphthylamine, C10H9N), H = Henry's Law Constant:
(References: Handbook of Physical Properties of Organic Chemicals & CRC Handbook of Chemistry and Physics, CRC Press)

$MW_{naph} := (10 \cdot 12.011 + 9 \cdot 1.0079 + 14.0067) \cdot \frac{gm}{mole}$ $\quad MW_{naph} = 143.188 \cdot \frac{gm}{mole}$

$\rho_{naph} := 1.0228 \cdot \frac{gm}{cm^3}$ $\quad \rho_{naph} = 8.536 \cdot \frac{lb}{gal}$

The source of alpha-Naphthylamine is the laboratory. Assume that 50 gallons of alpha-Naphthylamine was used per year.

$Volume_{naph} := 50 \cdot gal$

$$C_{naph} := \frac{\frac{Volume_{naph} \cdot \rho_{naph}}{MW_{naph}}}{2350000 \cdot gal} \qquad C_{naph} = 1.52 \cdot 10^{-4} \cdot \frac{mole}{liter}$$

$moles_{naph\_liquid} := C_{naph} \cdot Volume_{liquid}$ $\quad moles_{naph\_liquid} = 11.506 \cdot mol$

$H_{naph} := 4.64 \cdot 10^{-7} \cdot \frac{atm \cdot m^3}{mole}$

$P_{naph} := H_{naph} \cdot C_{naph}$ $\quad P_{naph} = 7.052 \cdot 10^{-8} \cdot atm$

$$moles_{naph\_vapor} := \frac{P_{naph} \cdot Volume_{vapor}}{R_{gas} \cdot T} \qquad moles_{naph\_vapor} = 2.729 \cdot 10^{-4} \cdot mole$$

$moles_{naph\_total} := (moles_{naph\_liquid} + moles_{naph\_vapor})$

$moles_{naph\_total} = 11.506 \cdot mole$

$Wt_{naph\_total} := moles_{naph\_total} \cdot MW_{naph}$

$Wt_{naph\_total} = 3.6 \cdot lb$ **There is no SQE limit for alpha-Naphthylamine**

For Tetrachloroethene (C2Cl4), H = Henry's Law Constant, S = Solubility in water by weight:
(Reference: Handbook of Physical Properties of Organic Chemistry, CRC Press)

$MW_{C2Cl4} := (2 \cdot 12.011 + 4 \cdot 35.453) \cdot \frac{gm}{mole}$ $\quad MW_{C2Cl4} = 165.834 \cdot \frac{gm}{mole}$

$H_{C2Cl4} := 1.72 \cdot 10^{-2} \cdot \frac{atm \cdot m^3}{mole}$ $\quad S_{C2Cl4} := 2.00 \cdot 10^{2} \cdot \frac{mg}{liter}$

$moles_{C2Cl4\_liquid} := \frac{S_{C2Cl4} \cdot Volume_{liquid}}{MW_{C2Cl4}}$ $\quad moles_{C2Cl4\_liquid} = 91.306 \cdot mol$

$C_{C2Cl4} := \frac{moles_{C2Cl4\_liquid}}{Volume_{liquid}}$ $\quad C_{C2Cl4} = 1.206 \cdot 10^{-3} \cdot \frac{mole}{liter}$

$P_{C2Cl4} := H_{C2Cl4} \cdot C_{C2Cl4}$ $\quad P_{C2Cl4} = 0.021 \cdot atm$

$moles_{C2Cl4\_vapor} := \frac{P_{C2Cl4} \cdot Volume_{vapor}}{R_{gas} \cdot T}$ $\quad moles_{C2Cl4\_vapor} = 80.28 \cdot mole$

$moles_{C2Cl4\_total} := \left(moles_{C2Cl4\_liquid} + moles_{C2Cl4\_vapor}\right)$

$moles_{C2Cl4\_total} = 171.586 \cdot mole$

$Wt_{C2Cl4\_total} := moles_{C2Cl4\_total} \cdot MW_{C2Cl4}$

$Wt_{C2Cl4\_total} = 62.7 \cdot lb$ $\quad SQE_{C2Cl4} := 500 \cdot \frac{lb}{yr}$

For Toluene (C7H8), H = Henry's Law Constant, S = Solubility in water by weight: (Reference: Handbook of Physical Properties of Organic Chemistry, CRC Press)

$$MW_{Toluene} := (7 \cdot 12.011 + 8 \cdot 1.0079) \cdot \frac{gm}{mole} \qquad MW_{Toluene} = 92.14 \cdot \frac{gm}{mole}$$

$$H_{Toluene} := 6.64 \cdot 10^{-3} \cdot \frac{atm \cdot m^3}{mole} \qquad S_{Toluene} := 5.26 \cdot 10^{2} \cdot \frac{mg}{liter}$$

$$moles_{Toluene\_liquid} := \frac{S_{Toluene} \cdot Volume_{liquid}}{MW_{Toluene}} \qquad moles_{Toluene\_liquid} = 432.195 \cdot mol$$

$$C_{Toluene} := \frac{moles_{Toluene\_liquid}}{Volume_{liquid}} \qquad C_{Toluene} = 5.709 \cdot 10^{-3} \cdot \frac{mole}{liter}$$

$$P_{Toluene} := H_{Toluene} \cdot C_{Toluene} \qquad P_{Toluene} = 0.038 \cdot atm$$

$$moles_{Toluene\_vapor} := \frac{P_{Toluene} \cdot Volume_{vapor}}{R_{gas} \cdot T} \qquad moles_{Toluene\_vapor} = 146.699 \cdot mole$$

$$moles_{Toluene\_total} := \left(moles_{Toluene\_liquid} + moles_{Toluene\_vapor}\right)$$

$$moles_{Toluene\_total} = 578.894 \cdot mole$$

$$Wt_{Toluene\_total} := moles_{Toluene\_total} \cdot MW_{Toluene}$$

$$Wt_{Toluene\_total} = 117.6 \cdot lb \qquad SQE_{Toluene} := 43748 \cdot \frac{lb}{yr}$$

For Xylene (C8H10), H = Henry's Law Constant, S = Solubility in water by weight: (Reference: Handbook of Physical Properties of Organic Chemistry, CRC Press)

$MW_{Xylene} := (8 \cdot 12.011 + 10 \cdot 1.0079) \cdot \frac{gm}{mole}$ $\qquad MW_{Xylene} = 106.167 \cdot \frac{gm}{mole}$

$H_{Xylene} := 7.53 \cdot 10^{-3} \cdot \frac{atm \cdot m^3}{mole}$ (P-isomer, bounding)

$S_{Xylene} := 1.78 \cdot 10^{2} \cdot \frac{mg}{liter}$ (O-isomer, bounding)

$moles_{Xylene\_liquid} := \frac{S_{Xylene} \cdot Volume_{liquid}}{MW_{Xylene}}$ $\qquad moles_{Xylene\_liquid} = 126.933 \cdot mol$

$C_{Xylene} := \frac{moles_{Xylene\_liquid}}{Volume_{liquid}}$ $\qquad C_{Xylene} = 1.677 \cdot 10^{-3} \cdot \frac{mole}{liter}$

$P_{Xylene} := H_{Xylene} \cdot C_{Xylene}$ $\qquad P_{Xylene} = 0.013 \cdot atm$

$moles_{Xylene\_vapor} := \frac{P_{Toluene} \cdot Volume_{vapor}}{R_{gas} \cdot T}$ $\qquad moles_{Xylene\_vapor} = 146.699 \cdot mole$

$moles_{Xylene\_total} := (moles_{Xylene\_liquid} + moles_{Xylene\_vapor})$

$moles_{Xylene\_total} = 273.631 \cdot mole$

$Wt_{Xylene\_total} := moles_{Xylene\_total} \cdot MW_{Xylene}$

$Wt_{Xylene\_total} = 64 \cdot lb$ $\qquad SQE_{Xylene} := 43748 \cdot \frac{lb}{yr}$

For 1,2,4-Trichlorobenzene (C6H3Cl3), H = Henry's Law Constant, S = Solubility in water by weight: (Reference: Handbook of Physical Properties of Organic Chemistry, CRC Press)

$MW_{124TCB} := (6 \cdot 12.011 + 3 \cdot 1.0079 + 3 \cdot 35.453) \cdot \frac{gm}{mole}$ $MW_{124TCB} = 181.449 \cdot \frac{gm}{mole}$

$H_{124TCB} := 1.42 \cdot 10^{-3} \cdot \frac{atm \cdot m^3}{mole}$

$S_{124TCB} := 4.90 \cdot 10^{1} \cdot \frac{mg}{liter}$

$moles_{124TCB\_liquid} := \frac{S_{124TCB} \cdot Volume_{liquid}}{MW_{124TCB}}$ $moles_{124TCB\_liquid} = 20.445 \cdot mol$

$C_{124TCB} := \frac{moles_{124TCB\_liquid}}{Volume_{liquid}}$ $C_{124TCB} = 2.7 \cdot 10^{-4} \cdot \frac{mole}{liter}$

$P_{124TCB} := H_{124TCB} \cdot C_{124TCB}$ $P_{124TCB} = 3.835 \cdot 10^{-4} \cdot atm$

$moles_{124TCB\_vapor} := \frac{P_{124TCB} \cdot Volume_{vapor}}{R_{gas} \cdot T}$ $moles_{124TCB\_vapor} = 1.484 \cdot mole$

$moles_{124TCB\_total} := (moles_{124TCB\_liquid} + moles_{124TCB\_vapor})$

$moles_{124TCB\_total} = 21.929 \cdot mole$

$Wt_{124TCB\_total} := moles_{124TCB\_total} \cdot MW_{124TCB}$

$Wt_{124TCB\_total} = 8.8 \cdot lb$ $SQE_{124TCB} := 17500 \cdot \frac{lb}{yr}$

For Tributyl Phosphate [(C4H9O)3PO], H = Henry's Law Constant, S = Solubility in water by weight: (Reference: Handbook of Physical Properties of Organic Chemistry, CRC Press)

$$MW_{TBP} := (12\cdot 12.011 + 27\cdot 1.0079 + 4\cdot 15.9994 + 1\cdot 30.9738)\cdot\frac{gm}{mole} \qquad MW_{TBP} = 266.317\,\frac{gm}{mole}$$

$$H_{TBP} := 1.50\cdot 10^{-7}\cdot\frac{atm\cdot m^3}{mole} \qquad S_{TBP} := 2.8\cdot 10^{2}\cdot\frac{mg}{liter}$$

$$moles_{TBP\_liquid} := \frac{S_{TBP}\cdot Volume_{liquid}}{MW_{TBP}} \qquad moles_{TBP\_liquid} = 79.598\,mol$$

$$C_{TBP} := \frac{moles_{TBP\_liquid}}{Volume_{liquid}} \qquad C_{TBP} = 1.051\cdot 10^{-3}\,\frac{mole}{liter}$$

$$P_{TBP} := H_{TBP}\cdot C_{TBP} \qquad P_{TBP} = 1.577\cdot 10^{-7}\,atm$$

$$moles_{TBP\_vapor} := \frac{P_{TBP}\cdot Volume_{vapor}}{R_{gas}\cdot T} \qquad moles_{TBP\_vapor} = 6.103\cdot 10^{-4}\,mole$$

$$moles_{TBP\_total} := \left(moles_{TBP\_liquid} + moles_{TBP\_vapor}\right) \qquad moles_{TBP\_total} = 79.599\,mole$$

$$Wt_{TBP\_total} := moles_{TBP\_total}\cdot MW_{TBP}$$

$$Wt_{TBP\_total} = 46.735\,lb \qquad SQE_{TBP} := 175\cdot\frac{lb}{yr}$$

For Dibutyl Phosphate [(C4H9O)2POOH]:

$$MW_{DBP} := (8\cdot 12.011 + 19\cdot 1.0079 + 4\cdot 15.9994 + 1\cdot 30.9738)\cdot\frac{gm}{mole} \qquad MW_{DBP} = 210.21 \circ \frac{gm}{mole}$$

Each mole of TBP is capable of ultimately producing 1 moles of Dibutyl Phosphate through radiolytic decay. Assuming complete conversion of TBP to DBP:

$$moles_{TBP\_total} = 79.599 \bullet mol$$

$$moles_{DBP\_total} := 1\cdot moles_{TBP\_total} \qquad moles_{DBP\_total} = 79.599 \circ mole$$

$$Wt_{DBP\_total} := moles_{DBP\_total}\cdot MW_{DBP}$$

$$Wt_{DBP\_total} = 36.889 \circ lb \qquad SQE_{DBP} := 1750\cdot\frac{lb}{yr}$$

For n-Butanol(C4H10O):

$$MW_{Butanol} := (4\cdot 12.011 + 10\cdot 1.0079 + 15.9994)\cdot\frac{gm}{mole} \qquad MW_{Butanol} = 74.122 \circ \frac{gm}{mole}$$

Each mole of TBP is capable of ultimately producing 3 moles of Butanol through radiolytic decay. Assuming complete conversion of TBP to Butanol;

$$moles_{TBP\_total} = 79.599 \bullet mol$$

$$moles_{Butanol\_total} := 3\cdot moles_{TBP\_total} \qquad moles_{Butanol\_total} = 238.796 \circ mole$$

$$Wt_{Butanol\_total} := moles_{Butanol\_total}\cdot MW_{Butanol}$$

$$Wt_{Butanol\_total} = 39.022 \circ lb \qquad SQE_{Butanol} := 43748\cdot\frac{lb}{yr}$$

For Benzene (C6H6), H = Henry's Law Constant, S = Solubility in water by weight:
(Reference: Handbook of Physical Properties of Organic Compounds, CRC Press)

$MW_{Benzene} := (6 \cdot 12.011 + 6 \cdot 1.0079) \cdot \frac{gm}{mole}$ $\quad MW_{Benzene} = 78.113 \cdot \frac{gm}{mole}$

$H_{Benzene} := 5.55 \cdot 10^{-3} \cdot \frac{atm \cdot m^3}{mole}$ $\quad S_{Benzene} := 1.79 \cdot 10^{3} \cdot \frac{mg}{liter}$

$Dilution\_Factor_{Benzene} := \frac{6}{2353}$ $\quad Dilution\_Factor_{Benzene} = 2.55 \cdot 10^{-3}$

$$moles_{Benzene\_liquid} := \frac{S_{Benzene} \cdot Volume_{liquid} \cdot Dilution\_Factor_{Benzene}}{MW_{Benzene}}$$

$moles_{Benzene\_liquid} = 4.424 \cdot mol$

$C_{Benzene} := \frac{moles_{Benzene\_liquid}}{Volume_{liquid}}$ $\quad C_{Benzene} = 0.058 \cdot \frac{mole}{m^3}$

$P_{Benzene} := H_{Benzene} \cdot C_{Benzene}$ $\quad P_{Benzene} = 3.243 \cdot 10^{-4} \cdot atm$

$moles_{Benzene\_vapor} := \frac{P_{Benzene} \cdot Volume_{vapor}}{R_{gas} \cdot T}$ $\quad moles_{Benzene\_vapor} = 1.255 \cdot mole$

$$Wt_{Benzene\_total} := \left(moles_{Benzene\_liquid} + moles_{Benzene\_vapor}\right) \cdot MW_{Benzene}$$

$Wt_{Benzene\_total} = 0.978 \cdot lb$ $\quad SQE_{Benzene} := 20 \cdot \frac{lb}{yr}$

Estimation of Criteria Pollutants (WAC 173-400):

$Wt_{Acids} := Wt_{AA\_total} + Wt_{OA\_total}$ $\qquad Wt_{Acids} = 5.789 \cdot lb$

$Wt_{Alcohol} := Wt_{Butanol\_total}$ $\qquad Wt_{Alcohol} = 39.022 \cdot lb$

$A := Wt_{Acetone\_total} + Wt_{Benzene\_total} + Wt_{Chloroform\_total} + Wt_{CCl4\_total} + Wt_{DBP\_total}$

$B := Wt_{C2Cl4\_total} + Wt_{TBP\_total} + Wt_{124TCB\_total} + Wt_{Toluene\_total} + Wt_{Xylene\_total}$

$C := Wt_{CCl2F2\_total} + Wt_{naph\_total}$

$Wt_{Organic\_liquids} := A + B + C$ $\qquad Wt_{Organic\_liquids} = 1236.4 \cdot lb$

$Wt_{VOC} := Wt_{Acids} + Wt_{Alcohol} + Wt_{Organic\_liquids}$

$Wt_{VOC} = 1281.2 \cdot lb$ $\qquad Wt_{VOC} = 0.641 \cdot ton$ $\qquad$ [Small Quanty Exemption Limit is 2 tons/year (WAC 173-400-110(5)(d)]

ESTIMATION OF PARTICULATE MATTER (PM) AND PARTICULATE MATTER 10 MICRONS OR LESS IN DIAMETER (PM10)

The estimated volume of soil to be removed is 1.0 cubic yd with an average density of 97.5 pounds per cubic feet assuming loose sand and gravel (Marks' Standard Handbook for Mechanical Engineers, 9th Edition).

$Soil_{volume} := 1 \cdot yd^3$

$\rho_{soil} := 97.5 \cdot \frac{lb}{ft^3}$

$Soil_{mass} := Soil_{volume} \cdot \rho_{soil}$

$Soil_{mass} = 2.632 \cdot 10^3 \cdot lb$

$Soil_{mass} = 1 \cdot ton$

Using the methodology of AP-42 for aggregate handling and storage piles (13.2.4) with no controls to prevent fugitive dust from becoming airborne, the release factor for particulate matter (PM, less than 100 micrometers) and PM-10 (particulate matter less than 10 micrometers) will be calculated. Sandy material (89% sand, 7% silt and 4% clay) on the Hanford Site has been analyzed for particle distribution data (PNNL-8889). Based on the distribution data, approximately 12% of the sandy material has a particle size of 100 micrometers or less, 9% has a particle size of 30 micrometers or less and approximately 8% of the total consists of particles 10 micrometers or less.

The exempt source thresholds under the table in WAC 173-400-110(5)(d) for PM is 1.25 tons per year and for PM-10 is 0.75 tons per year. Based on Fugitive Dust Sources from Section 13.2 of AP-42, using a typical wind speed of 10 miles per hour, particles larger than about 100 micrometers are likely to settle out within 20 to 30 feet from the point of emission and particles between 30 to 100 micrometers in diameter are likely to settle out within a few hundred feet from the source; therefore, based on the discussion in AP-42, particles greater than 30 micrometers will not leave the site since the nearest receptor for activities associated with Project W-314 is approximately 16,000 meters (52,500 feet) (WHC-0498) away. The moisture content (M) was conservatively choosen as 0.25% since that is the minimium moisture content range for the AP-42 equation that follows.

$U := 10 \cdot \frac{mi}{hr}$ (wind speed)

$M := .25$ (% material moisture content)

$k_{30} := .74$ (aerodynamic particle size multiplier, AP-42)

$$E_{30} := k_{30} \cdot .0032 \cdot \frac{\left(\frac{U}{5 \cdot \frac{mi}{hr}}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \cdot \frac{lb}{ton} \qquad E_{30} = 0.107 \cdot \frac{lb}{ton}$$

$Soil30_{released} := E_{30} \cdot Soil_{mass}$

$Soil30_{released} = 0.141 \cdot lb$ $\qquad$ $Soil30_{released} = 7.053 \cdot 10^{-5} \cdot ton$

$PM_{standard} := 1.25 \cdot ton$

$k_{10} := .35$

$$E_{10} := k_{10} \cdot .0032 \cdot \frac{\left(\frac{U}{5 \cdot \frac{mi}{hr}}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \cdot \frac{lb}{ton} \qquad E_{10} = 0.051 \cdot \frac{lb}{ton}$$

$$Soil10_{released} := E_{10} \cdot Soil_{mass}$$

$Soil10_{released} = 0.067 \cdot lb$ $\qquad$ $Soil10_{released} = 3.336 \cdot 10^{-5} \cdot ton$

$PM10_{standard} := 0.75 \cdot ton$